

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 3: Provide a technical basis for DOE's assessment of loss of cooling capabilities at the surface facilities. They are needed to assess whether loss of cooling can initiate an event sequence at the repository facilities. DOE references the following documents but these have not been provided:

BSC 2007. "Thermal Evaluation of the CRCF-1 Lower Transfer Room Cells." 060-00C-DS00-00100-000-00A. Las Vegas, Nevada. Bechtel SAIC Company.

BSC 2008a. "Pool Water Treatment and Cooling System." 050-M0C-PW00-00100-000-00C. Las Vegas, Nevada: Bechtel SAIC Company.

BSC 2008b. "WHF and RF Thermal Evaluation." 000-00C-DS00-01200-000-00A. Las Vegas, Nevada. Bechtel SAIC Company.

1. RESPONSE

1.1 INTRODUCTION

This response addresses the external events identified in SAR Section 1.6.3.4.7. Eleven potential external hazards or events that could impact the repository water supply have been grouped and evaluated as a loss of cooling capability event as shown in SAR Table 1.6-8. The required water and cooling capabilities at the Yucca Mountain site surface waste handling facilities during the preclosure period are the following: (1) deionized makeup water needs for the Wet Handling Facility (WHF) pool, (2) chilled water needs of the WHF pool water heat exchangers, and (3) chilled water to not important to safety (non-ITS) heating, ventilation, and air conditioning (HVAC) systems serving nonconfinement HVAC functions (SAR Sections 1.2.5.3.2.1.3.2, 1.4.4.4.1, and 1.4.4.5.1).

A loss of water supply to the Yucca Mountain surface waste handling facilities will not initiate an event sequence, as discussed in the following sections and supported by the three requested documents, which are being provided with this response.

1.2 WET HANDLING FACILITY POOL

The WHF pool has a water depth of 48 ft during normal operations. To reach the minimum pool water shielding level of 35 ft, the pool level would need to be reduced by 13 ft of water. Assuming the maximum heat load, the maximum evaporation rate, and a maximum pool temperature of approximately 102°F, it would take approximately 180 days without makeup water to the pool for the pool water level to reach the minimum shielding level of 35 ft (SAR Section 1.2.5.3.2.2).

The WHF pool water is normally maintained at 75°F (SAR Section 1.2.5.3.2.2). Assuming the maximum heat load, full pool water volume, and no heat loss due to evaporation, it would take approximately 86 days with a loss of cooling water to the WHF pool water heat exchangers to raise the pool water temperature from 75°F to 206°F, the boiling point of water at the repository

elevation. Assuming the maximum heat load, minimum evaporative heat loss, and a starting pool temperature of 75°F, the final pool temperature following a 30-day outage of the pool cooling system would be approximately 105°F. Thirty days is a reasonable period of time to perform repairs and to restore systems to normal operations.

A procedural safety control (PSC-22) listed in SAR Table 1.9-10 has been established to ensure that the WHF pool level is maintained at least 23 ft above the active portions of the commercial spent nuclear fuel (SNF). The procedurally required water level is greater than the level needed for shielding of operators, which will also assure sufficient water volume for passive cooling needs. The pool water treatment and cooling system operating procedures will include a warning that the height of water above the top of active portions of commercial SNF assemblies in the WHF pool is an important constraint in the preclosure safety analysis. The procedure for conducting operator rounds will include monitoring the pool level. Pool water treatment and cooling system operating procedures will provide for manual make-up as necessary to restore the pool level to or above the minimum specified level (SAR Section 1.2.5.1.4 and SAR Table 1.9-10). Proposed licensing specifications, identified in SAR Table 5.10-3, include administrative controls that require the repository operating procedures to implement the procedural safety controls identified in SAR Table 1.9-10.

Because of PSC-22 and the amount of time available for operations personnel to respond to loss of makeup water to the WHF pool or a loss of cooling water to the WHF pool water heat exchangers, the loss of water cooling event with respect to the WHF pool is not considered as an initiating event. The slow development of the event will provide sufficient time for an adequate response.

1.3 HVAC SYSTEM CHILLED WATER

Portions of the non-ITS nonconfinement HVAC systems use chilled water, and a loss of that chilled water would reduce the cooling capability of the system. However, the loss of chilled water would not initiate an event sequence because loss of chilled water to rooms handling waste forms does not cause waste form or canister structural thermal limits to be exceeded.

Thermal calculations for waste packages, canisters, and handling equipment in the thermally limiting rooms were performed to determine their peak temperatures in the Canister Receipt and Closure Facility, WHF, and Receipt Facility. These evaluations of commercial SNF, DOE SNF, and high-level radioactive waste demonstrate that thermal performance of the waste forms, canisters, and waste packages is acceptable, given various heat loads during off-normal HVAC conditions (SAR Sections 1.2.2.3.6 and 1.2.4.4). Thus, event sequences cannot be initiated by a loss of chilled water to the HVAC systems in areas where waste forms are handled.

Thermal analyses have also been performed for assessing naval SNF temperatures during handling of naval SNF canisters in the Initial Handling Facility. The analyses confirm that the naval SNF canisters are maintained within the thermal limits identified in footnote (e) to SAR Table 1.9-8. Analyses discussed in Section 1.5.1.4 of the Naval Nuclear Propulsion Program Technical Support Document demonstrate that naval SNF structural integrity is maintained when the naval SNF canister external surface temperature remains below 400°F during a maximum 30-

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day period starting with detensioning of the transportation cask closure in the Initial Handling Facility and ending with waste package emplacement. Therefore, room heat-up from loss of cooling is not considered an initiating event and the cooling portion of the nuclear confinement HVAC system is classified as non-ITS (SAR Sections 1.2.2.3.6 and 1.2.4.4).

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 4: Explain why DOE used structural failure data from the International Atomic Energy Agency (2003) to screen out structural failure by tornadoes rather than using data from Texas Tech University (2006).

Section A3.4 of BSC (2008d), as referenced in SAR section 1.6, screens out structural failure from tornado strikes at 95 percent probability of occurrence using the data provided by the International Atomic Energy Agency (2003). However, as discussed in Section A3.4 of BSC (2008d), the structural failure probability would be above the screening threshold if data from Texas Tech University (2006) were used.

References:

International Atomic Energy Agency 2003. "External Events Excluding Earthquakes in the Design of Nuclear Power Plants, Safety Guide." Safety Standards Series No. NS-G- 1.5. Vienna, Austria: International Atomic Energy Agency.

Texas Tech University 2006. "A Recommendation for an Enhanced Fujita Scale (EF-Scale)." Revision 2. Lubbock, Texas: Texas Tech University, Wind Science and Engineering Center.

1. RESPONSE

Structural damage data from *A Recommendation for an Enhanced Fujita Scale (EF-Scale)* (Texas Tech University 2006), coupled with the tornado strike frequency information in *Tornado Climatology of the Contiguous United States*, NUREG/CR-4461 (Ramsdell and Rishel 2007), are used as the basis for screening out tornado induced structural failure of the waste handling facilities. The discussion in Section A.3.2 on Page A-11 of *External Events Hazards Screening Analysis* (BSC 2008) cites the Texas Tech University information as the basis for the structural failure analysis. The approach for screening an event from further analysis is to determine if the mean probability of the initiating event is less than 1×10^{-4} over the preclosure period (100 years). The mean value of the tornado strike frequency was used to screen out structural failure as a result of a tornado strike.

Section A3.4 of the *External Events Hazards Screening Analysis* (BSC 2008) uses *External Events Excluding Earthquakes in the Design of Nuclear Power Plants, Safety Guide* (IAEA 2003) within a discussion of sensitivities and uncertainties and not as the basis for screening out tornado induced structural damage. As part of evaluating the full range of uncertainty, the screening analysis shows that a hypothetical use of the 95 percentile of the tornado strike frequency combined with a maximum error factor of 3.8, along with the conservatively selected surrogate structure (the overhead door of the entry vestibule), would result in a structural failure probability greater than the screening criterion. Section A3.4 of the screening analysis then describes how the use of a different structural analysis approach (IAEA 2003) than that selected

for the screening analysis in Section A3.2 would still result in screening out tornado induced damage.

In summary, information from *A Recommendation for an Enhanced Fujita Scale (EF Scale)* (Texas Tech University 2006) and NUREG/CR-4461 (Ramsdell and Rishel 2007) was used in the tornado screening analysis. Based on this information, the probability of structural failure of the waste handling buildings due to a tornado strike was determined to be less than the screening threshold.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2008. *External Events Hazards Screening Analysis*. 000-00C-MGR0-00500-000-00C. Las Vegas, Nevada: Bechtel SAIC Company.
ACC: ENG.20080219.0001; ENG.20080310.0025; ENG.20080828.0009.

IAEA (International Atomic Energy Agency) 2003. “External Events Excluding Earthquakes in the Design of Nuclear Power Plants, Safety Guide.” Safety Standards Series No. NS-G- 1.5. Vienna, Austria: International Atomic Energy Agency.

Ramsdell, J.V., Jr., and Rishel, J.P. 2007. *Tornado Climatology of the Contiguous United States*. NUREG/CR-4461, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission.
ACC: MOL.20071114.0166.

Texas Tech University 2006. *A Recommendation for an Enhanced Fujita Scale (EF Scale)*, Rev. 2. Lubbock, Texas: Texas Tech University, Wind Science and Engineering Center.
ACC: MOL.20071115.0063.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 5: Provide the analysis referenced in SAR Section 1.6.3.4.4 High Winds and Tornadoes that documents the development of straight wind hazard curve DOE used to support its PCSA. This information is needed to determine whether the estimated 3-second gust straight wind speed for the million-year recurrence interval adequately estimated. DOE references the following document but this has not been provided:

BSC 2007. "Straight Wind Hazard Curve Analysis." 000-00A-MGR0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company.

1. RESPONSE

The analysis referenced in SAR Section 1.6.3.4.4, "High Winds and Tornadoes," that documents the development of straight wind hazard curves, *Straight Wind Hazard Curve Analysis* (BSC 2007), is provided with this response.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC 2007. *Straight Wind Hazard Curve Analysis*. 000-00A-MGR0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071023.0002.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 7: Define and provide justification for screening out the following external hazards, identified in SAR Table 1.6-8 External Event Identification and Crosswalk to Assigned Categories, as being the potential initiator of event sequences:

- (a) Rockburst
- (b) Soil Shrink-Swell Consolidation
- (c) Static Fracturing
- (d) Geochemical Alterations
- (e) Perturbation of Groundwater System
- (f) Thermal Loading
- (g) Undetected Past Human Intrusions
- (h) Barometric Pressure
- (i) Extreme Weather and Climate Fluctuation.

DOE identified these as potential hazards but did not provide any description of these or a technical basis for screening these out.

1. RESPONSE

SAR Section 1.6.3.2, “Identification of External Initiating Events,” provides a description of the process used to identify potential external events and group them with events that have common features or similar characteristics. SAR Table 1.6-8 provides the grouping of the 89 identified potential external hazards or events into 13 categories that were evaluated. The supporting calculation for external hazards is *External Events Hazards Screening Analysis* (BSC 2008). On the basis of the NRC clarification call of April 9, 2009, this response addresses how each of the above external hazards was grouped within the 13 analysis categories and then further analyzed in *External Events Hazards Screening Analysis* (BSC 2008).

1.1 ROCKBURST, SOIL SHRINK-SWELL CONSOLIDATION, AND STATIC FRACTURING

Rockburst, soil shrink-swell consolidation, and static fracturing are grouped with the nonseismic geologic activity external event category in SAR Table 1.6-8.

Rockburst is a sudden breaking of a mass of rock from the walls of a tunnel, mine, or deep quarry caused by the release of accumulated strain energy. Rockburst may result in a closure of a mine opening or a projection of broken rock into a mine. Rockburst characteristics are similar to those of emplacement drift degradation. Drift degradation is the partial or complete collapse of access tunnels, ramps, turnouts, or emplacement drifts as a result of nonseismic rockburst or rockfall. Therefore, rockburst is addressed with drift degradation in Section 6.2.2 of the screening analysis (BSC 2008). Drift degradation is discussed in SAR Section 1.6.3.4.2. Nonseismic drift degradation is not evaluated further because drift degradation due to seismic ground motion is the controlling mechanism during the preclosure period. Seismic drift degradation is considered as part of the seismic external event, which is evaluated as an external initiating event in SAR Section 1.7.

Static fracturing can result from soil shrink-swell consolidation due to the fissuring and cracking of the ground. Soils with high clay content, particularly expanding clay, can change volume with changes in moisture content due to wetting and drying (shrink and swell). Soil shrink-swell consolidation has been grouped with avalanche for purposes of analysis because of the potential for soil loosening on slopes due to soil volume changes contributing to a landslide.

Avalanche is discussed in SAR Section 1.6.3.4.2 and screened from further consideration. Avalanches typically occur on sloped terrain found in alpine mountain ranges in conjunction with substantial snow pack. Yucca Mountain is not located in the immediate vicinity of alpine mountains. Its present day climate is relatively arid, characterized by hot summers and dry, cool winters. Mountain ranges to the west of Yucca Mountain form a significant impediment to the movement of Pacific air, especially during the winter, resulting in a rain shadow effect. Annual precipitation totals range between 100 and 300 mm/yr. The heaviest precipitation at Yucca Mountain normally occurs during late July. Therefore, Yucca Mountain's relatively arid climate would preclude the accumulation of significant snow and ice necessary for an avalanche.

In addition, because of Yucca Mountain's relatively arid climate, moisture availability is limited. Therefore, the likelihood that any clay-rich soils would be exposed to sufficient wetting and drying to exhibit shrink and swell consolidation is negligible. Thus, avalanches and landslides were excluded from further consideration.

1.2 GEOCHEMICAL ALTERATION, PERTURBATION OF GROUNDWATER SYSTEM, THERMAL LOADING, AND UNDETECTED PAST HUMAN INTRUSIONS

Geochemical alteration, perturbation of groundwater system, thermal loading, and undetected past human intrusions are identified as not applicable events in SAR Table 1.6-8.

Geochemical alteration concerns alteration of host-rock properties. Thermal loading concerns the effects on the repository drifts from the waste package residual heat. SAR Section 1.1.8 describes the potential for geochemical alteration due to heating (thermal loading) and other processes to alter host-rock properties during the preclosure period. SAR Section 1.1.5.3.1 describes the underground facilities and thermal properties of the rock mass. Preclosure thermal effects are considered in the design and are managed by the design of the underground layout, waste package loading, emplacement drift loading, and heat removal during the preclosure period. The layout design provides space and configuration for emplacement of the waste packages to minimize thermal impact on the natural barriers (SAR Section 1.3.2). SAR Section 1.1.8 indicates that forced ventilation during the preclosure period effectively dries out the near-field host rock and controls drift temperature. This ensures that intact rock physical, mechanical, and thermal properties are not significantly affected because such small quantities of minerals are dissolved, precipitated, or otherwise altered in the near-field host rock. Therefore, the host rock is not significantly affected by geochemical alterations and thermal loading during the preclosure period.

Perturbation of the groundwater system concerns long-term changes to water sources, such as the development of new population centers, that would create an additional demand for water. This

event is not applicable because it would proceed at a rate either too slow to affect the repository in the preclosure time period, or this perturbation would allow for sufficient time to develop alternative solutions to offset any effect of an additional demand for water.

Undetected past human intrusion concerns the hazards associated with undiscovered boreholes or mine shafts. The effect of undetected past human intrusion is a postclosure concern that is identified in SAR Table 2.2-1. Past human intrusion would either be detected during construction, or the erosion of the condition would proceed at a rate too slow to affect the repository facilities during the preclosure period. The screening analysis (BSC 2008, Section 4.4) states that external events that proceed at a rate too slow to affect the repository in the preclosure time period are excluded from further consideration on this basis.

1.3 BAROMETRIC PRESSURE

Barometric pressure is grouped with the high winds and tornados external event category in SAR Table 1.6-8.

Barometric pressure external events concern inclement weather associated with pressure changes. Rapidly falling barometric pressure generally signals the onset of stormy weather. As such, barometric pressure was grouped with high winds and tornadoes. SAR Section 1.6.3.4.4 summarizes the analyses performed to screen out high winds and tornadoes as external events. The important to safety surface facilities are designed to withstand the effects of tornado winds pressures, differential pressures, and rate of pressure drop (SAR Sections 1.2.2.1.6.1 and 1.2.2.1.6.1.2).

1.4 EXTREME WEATHER AND CLIMATE FLUCTUATION

Extreme weather and climate fluctuation is grouped with the high winds and tornados, external floods, loss of power, and loss of cooling external event categories in SAR Table 1.6-8.

Extreme weather and climate fluctuation is defined as weather or climatic conditions exceeding the normal limits of variability and includes flooding, extreme heat, extreme cold, drought, and high winds. Aspects of extreme weather and climate fluctuation have been addressed as part of several external event categories. High winds and tornadoes, discussed and screened from further evaluation in SAR Section 1.6.3.4.4, include high wind gusts. External floods, which include extreme rain and flooding, are discussed and screened from further evaluation in SAR Section 1.6.3.4.5. Loss of cooling capability, discussed and screened from further evaluation in SAR Section 1.6.3.4.7, includes conditions brought about by drought, extreme heat, and freezing temperatures. Extreme weather can cause downed power lines resulting in a loss of power event. SAR Section 1.6.3.4 and SAR Table 1.6-2 state that a loss of power event is not screened out; it is evaluated in the event sequence analysis presented in SAR Section 1.7.1.3.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC 2008. *External Events Hazards Screening Analysis*. 000-00C-MGR0-00500-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080219.0001; ENG.20080310.0025; ENG.20080828.0009.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 13: Identify where in the referenced source documents the initiating events listed in SAR Table 1.6-3 can be identified and how these are linked to the Master Logic Diagrams. For example, it is not clear how to trace through the SAR and supporting documents, “Impact from platform operations – 1” separately from “Impact from platform operations – 2” identified in this table on page 1.6-54 of the SAR.

1. RESPONSE

The table numbers in the source documents where internal initiating events listed in SAR Table 1.6-3 are identified for each facility and where links are provided between internal initiating events and master logic diagrams (MLD) are as follows for each facility:

- Canister Receipt and Closure Facility (BSC 2008a, Table 10)
- Initial Handling Facility (BSC 2008b, Table 10)
- Intrasite/Balance of Plant (BSC 2008c, Table 10)
- Receipt Facility (BSC 2008d, Table 10)
- Subsurface (BSC 2008e, Table 11)
- Wet Handling Facility (BSC 2008f, Table 10).

The tables listed above for each source document include an “Identifier” column that provides the MLD index number for each internal initiating event. The MLD index number provides traceability of initiating events through the SAR and within MLD figures, hazard and operability (HAZOP) tables, and event sequence diagram figures. For specific traceability, the tables also include columns with cross-references to each MLD figure, HAZOP table, and event sequence diagram figure associated with each internal initiating event.

As an example, SAR Table 1.6-3 includes the Canister Receipt and Closure Facility (CRCF) initiating event description “Canister transfer machine drops object onto cask or canister.” That initiating event appears in the “General Event Description” column of Table 10 of *Canister Receipt and Closure Facility Event Sequence Development Analysis* (BSC 2008a) with an MLD index number CRC-1401 in the “Identifier” column as shown in Table 1.

Table 1. Example of List of Internal Initiating Events Table

Identifier	General Event Description	MLD Figure #	HAZOP Table #	ESD Figure #
CRC-1401	CTM drops object onto cask or canister	D-14	E-14	F-9

Source: BSC 2008a, Table 10.

NOTE: CTM = Canister transfer machine, ESD = event sequence diagram.

Table 10 of the CRCF event sequence analysis (BSC 2008a) also provides cross-references to the associated HAZOP Table E-14, MLD Figure D-14, and event sequence diagram Figure F-9 in the CRCF event sequence analysis (BSC 2008a). HAZOP Table E-14 in the CRCF event sequence analysis (BSC 2008a) is the hazard evaluation worksheet that includes that initiating event and provides the MLD index number CRC-1401 in the last column. MLD Figure D-14 of the CRCF event sequence analysis (BSC 2008a) also includes that initiating event and its MLD

index number CRC-1401 in an event node description. Event sequence diagram Figure F-9 in the CRCF event sequence analysis (BSC 2008a) summarizes the event sequences related to structural challenges that may occur during transfer of a canister by a canister transfer machine in the CRCF. It includes CRC-1401 at the small bubble for initiating events of the type “Drop of object onto canister.” Thus, initiating events in SAR Section 1.6 can be linked to MLDs and traced through the SAR and supporting documents.

On occasion, identical initiating events occur in more than one event sequence applicable to a facility. On those occasions, the initiating event descriptions in SAR Table 1.6-3 are numbered sequentially, as indicated in the note to SAR Table 1.6-3. The numbered initiating events can be associated with their unique MLD index number using the “General Event Description” column in the facility source document table from the list shown above for each facility. The value of a numbered initiating event corresponds to its sequence in the “General Event Description” column in the source document table. The first occurrence of an initiating event in the “General Event Description” column corresponds to initiating event “—1”, and so on. The MLD index number in the “Identifier” column for that event provides traceability through the SAR and within MLD figures, HAZOP tables, and event sequence diagram figures as described above. Although a unique MLD can be associated with each like-named initiating event, there is no analytical significance to the numerical sequence of like-named initiating events; it merely identifies that there is more than one like-named event in the source document references.

As an example of assigning unique identifiers, SAR Table 1.6-3 provides descriptions of four Wet Handling Facility initiating events: “Impact from platform operations—1,” “Impact from platform operations—2,” “Impact from platform operations—3,” and “Impact from platform operations—4.” In the “General Event Description” column of Table 10 of *Wet Handling Facility Event Sequence Development Analysis* (BSC 2008f), “Impact from platform operations” has MLD index numbers WHF-509, WHF-514, WHF-1501, and WHF-2101 in the “Identifier” column, corresponding to the same initiating event, “Impact from platform operations,” which occurs in four different event sequence diagrams. Thus, numbered initiating events in SAR Table 1.6-3 can be traced through the SAR and supporting documents using MLD index numbers identified from the tables cited in the SAR Section 1.6 source documents.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC 2008a. *Canister Receipt and Closure Facility Event Sequence Development Analysis*. 060-PSA-CR00-00100-000-00A CACN 001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080221.0008; ENG.20080314.0005; ENG.20090109.0006.

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BSC 2008b. *Initial Handling Facility Event Sequence Development Analysis.* 51A-PSA-IH00-00100-000-00A CACN 002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080207.0005; ENG.20080314.0002; ENG.20080828.0010.

BSC 2008c. *Intra-Site Operations and BOP Event Sequence Development Analysis.* 000-PSA-MGR0-00800-000-00A CACN 002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080212.0004; ENG.20080314.0006; ENG.20080811.0001.

BSC 2008d. *Receipt Facility Event Sequence Development Analysis.* 200-PSA-RF00-00100-000-00A CACN 002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080211.0006; ENG.20080314.0004; ENG.20080828.0011.

BSC 2008e. *Subsurface Operations Event Sequence Development Analysis.* 000-PSA-MGR0-00400-000-00A CACN 002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080214.0004; ENG.20080314.0001; ENG.20080811.0002.

BSC 2008f. *Wet Handling Facility Event Sequence Development Analysis.* 050-PSA-WH00-00100-000-00A CACN 002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080225.0010; ENG.20080312.0009; ENG.20080314.0003.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 14: Justify that event sequence frequencies accurately capture the frequency for events or bound the frequency for events that may span more than one waste form and potentially more than one facility. For example, ESD18 in the Canister Receipt and Closure Facility involves a direct exposure during transfer operations with the Canister Transfer Machine. There are separate event sequence frequencies for different waste forms; however, the events are similar regardless of the waste form. In addition, ESD12A in the Initial Handling Facility also involves a direct exposure during transfer operations with the Canister Transfer Machine. The events are similar in this case, regardless of whether the event is in the Canister Receipt and Closure Facility or the Initial Handling Facility.

1. RESPONSE

Event frequencies for different waste form configurations involved in similar event sequences within the same or different facilities are not aggregated because of substantial differences in handling, throughput, robustness of waste form, and dose consequences among facilities and different waste forms. The preclosure safety analysis (PCSA) and the safety analysis strategies demonstrate the safety of the repository for each waste form configuration. The PCSA process provides a conservative representation of event sequences and has the flexibility to accommodate different safety analysis strategies for each waste form configuration.

1.1 EVENT SEQUENCE DEVELOPMENT BASIS

The development of event sequences in the PCSA is based on an accurate representation of repository operations that identifies event sequences extending to end states. In the case of the geologic repository operations area facilities and operations, event sequences differ due to different facility configuration and operations (e.g., different lift heights, number of lifts), equipment (although some equipment is similar or identical across facilities, there are differences in lifting/rigging), waste forms (which give rise to different container robustness and different source terms), throughputs, times of waste form residence, and safety analysis strategies.

Event sequences have been categorized one at a time, and the event sequence frequency is based on the entire event sequence that extends to an end state resulting in a potential radioactive material release or direct exposure. The potential release characteristics that define an end state, such as radionuclide inventory, damage fraction, partitioning, and release fractions, are dependent on the waste form configuration involved. Each waste form is handled in the repository somewhat differently and has different robustness with respect to damage or breach. This leads to different initiating event frequencies and different conditional probabilities of pivotal events. Therefore, the waste form configuration, among other parameters, is considered in developing and quantifying event sequences, and each waste form generates unique event sequences.

To achieve an acceptable design, safety analysis strategies are developed for each waste form to be received at the facility. Examples of different waste form safety analysis strategies are as follows:

- The strategy to demonstrate safety of DOE high-level radioactive waste (HLW) canisters is based on demonstrating that dose limits are met regardless of the categorization rather than on the probabilistic categorization of event sequences.
- A different strategy is used for DOE spent nuclear fuel (SNF) and naval canisters for which breaches were demonstrated to have a probability less than the Category 2 screening threshold (i.e., breach events involving those waste forms are so unlikely that doses do not need to be calculated).
- Analysis of the transportation, aging, and disposal (TAD) canisters includes both a probability aspect to determine categorization and a dose consequence aspect to determine compliance with 10 CFR 63.111.

Therefore, event sequences are developed separately for each facility's operations and for each waste form to obtain an accurate representation of event sequences. This representation also applies to external events that affect the site as a whole, such as an earthquake. Each building responds differently to an earthquake; therefore, the fragilities of the various buildings, as well as the fragilities of equipment within them, are different. These differences are represented in the PCSA.

1.2. EVENT SEQUENCE QUANTIFICATION AND CATEGORIZATION APPROACH

The PCSA process of event sequence quantification and categorization provides for many conservatisms including grouping similar initiating events into aggregated initiating events when determining event sequence frequencies and consolidating waste forms into a few waste form configurations. The approach used in the PCSA to determine event sequence frequencies (conditional probabilities) for each event sequence is provided in SAR Section 1.7.1. That section discusses the development of individual event sequences from initiating events. SAR Sections 1.7.3 and 1.7.4 discuss the quantification and grouping of event sequences for the purpose of categorization and discuss event sequences that may affect more than one waste form and event sequences that may affect the entire facility. The implemented PCSA process ensures that event sequence frequencies accurately capture the frequency of all potential events.

The quantification of an event sequence consists of calculating the expected number of occurrences of its initiating event over the preclosure period and the conditional probability associated with each pivotal event in the event sequence. Event sequences that belong to the same event tree set (i.e., initiating event tree and response event tree), pertain to the same type of waste form configuration, follow the same path through the event tree, and lead to the same end state are grouped together for purposes of categorization.

The different types of waste form configurations considered in the PCSA are as follows:

- Waste package
- Naval SNF canister, by itself, or in a transportation cask

- HLW canister, by itself, or in a transportation cask
- DOE standardized canister, by itself, or in a transportation cask
- TAD canister, by itself, in a transportation cask, a shielded transfer cask, or an aging overpack
- Dual-purpose canister (DPC), by itself, or in a transportation cask, a shielded transfer cask, or an aging overpack
- Transportation cask containing uncanistered SNF assemblies
- SNF assembly (when handled directly in the pool of the Wet Handling Facility)
- Low-level waste generated by waste handling activities in the geologic repository operations area.

Waste form throughputs used to determine event sequence frequencies are particularized to each relevant facility and include embedded scenarios that allow for flexibility in the conduct of operations. For example, TAD canisters that are shipped to the repository could be delivered to the Receipt Facility, or, alternatively, to a Canister Receipt and Closure Facility (CRCF). The PCSA uses the total number of received TAD canisters at the repository without apportioning them to one or another facility. This approach for TAD canisters inflates the number of estimated handlings and results in event sequences that are mutually exclusive between those facilities. Waste form throughputs particularized to a given facility are considered independently, and event sequence frequencies derived from them are not intended to be summed together. Summing them may result in double counting. Furthermore, as described above, differences in handling among facilities particularizes the event sequence to an individual facility.

More than one initiating event type (for example, the drop, collision, and other structural challenges that could affect a given waste form container and described in SAR Section 1.7 as “little bubbles”) may share the same event sequence diagram but give rise to event sequence frequencies that are quantified separately because the conditional probabilities of their pivotal events depend on their specific initiating event. It is appropriate for purposes of categorization to add, within a given event sequence diagram and for a given waste form configuration, event sequences that elicit the same combination of failure and success of pivotal events but emanate from different types of initiating events, represented by little bubbles on the event sequence diagram. Thus, the grouping of event sequences is depicted, in an event sequence diagram, by little bubbles pointing to a big bubble that represents the aggregated initiating event under which individual event sequences are combined for purposes of categorization. This aggregation process is illustrated in SAR Figures 1.7-1 and 1.7-3.

SAR Section 1.7.4 states that the PCSA includes waste forms appropriate to event sequences potentially affecting multiple waste forms. For example, the seismically induced event sequence leading to a collapse of a surface facility causes the breach of the waste form containers inside that facility. Similarly, a large fire affecting an entire facility also affects each of the waste form

containers inside that facility. For Category 2 event sequences that have the potential to affect more than one waste form within a facility, the material at risk for input to the dose calculation includes those affected. The PCSA determined that there are no Category 1 event sequences.

SAR Section 1.7.4 also discusses event sequences potentially affecting more than one waste form. The number of occurrences, over the preclosure period, of an event sequence affecting more than one type of waste form configuration (for instance, an HLW canister and a DOE standardized canister, or a TAD canister and a DPC) is equal to the number of occurrences of the event sequence, evaluated for one of the waste form configurations, multiplied by the probability that the other waste form configurations are present at the time the initiating event occurs. Because a probability is less than or equal to one, this number is not greater than the number of occurrences of the event sequence before multiplication by the probability. In the PCSA, the number of occurrences of an event sequence is calculated for a given waste form configuration, without adjustment for the probability of the presence of other waste form configurations.

In summary, the approach used in the PCSA to determine event sequence frequencies accurately captures the frequency for events that may span more than one waste form. Event sequences have been categorized one at a time, and the event sequence frequency is based on the entire event sequence extending to an end state that includes consideration of the waste form configuration, among other parameters. Waste forms appropriate to event sequences potentially affecting multiple waste forms are included in the material at risk for input to the dose calculation. Further, because of substantial differences in waste form distribution, throughput, and dose consequences between facilities, event sequences across facilities are not combined.

1.3 CANISTER TRANSFER MACHINE EXAMPLE

The RAI cites, as an example of similar events with different waste forms, event sequence diagram CRC-ESD-18 in the CRCF that involves a direct exposure during transfer operations using a canister transfer machine. Separate event sequence frequencies are calculated for the four different waste forms (HLW canisters, DOE standardized canisters, DPCs, or TAD canisters). They are included in similar transfer operations, but event sequence frequencies are not aggregated.

Although the above event sequences are included in similar transfer operations, event sequences associated with each waste form are different from one another due to different physical characteristics and lifting configurations, different consequences, and different numbers of waste form units involved. Further, waste form throughputs used to determine event sequence frequencies are particularized to each relevant waste form and facility because a) the failure modes associated with different waste forms within each facility are different (e.g., different human reliability associated with handling different waste forms) and b) summing across facilities would count that same TAD canister more than once. For example, those TAD canisters that are received in the CRCF cannot also be received in the Receipt Facility. This results in event sequences that are independent and mutually exclusive between facilities (BSC 2007). Event sequence frequencies are not intended to be summed together.

The RAI also cites IHF-ESD-12A in the Initial Handling Facility (IHF) that involves a direct exposure during transfer operations with two different waste forms (HLW canisters and naval SNF canisters). The events are similar to CRC-ESD-18, but event sequence frequencies are not aggregated with those for CRC-ESD-18. Naval transportation casks and naval SNF canisters shipped to the repository are delivered to the IHF. Naval SNF canisters are transferred from transportation casks to waste packages with one canister transfer machine handling operation each. The naval SNF canisters are a unique waste form configuration only processed in the IHF. The naval SNF canisters have different weights, dimensions, lifting/rigging equipment, shielding requirements, and operational procedures to consider and model. Therefore, the IHF event sequences associated with naval SNF are not aggregated with similar operational event sequences for other waste forms in the CRCF or any other waste handling facility.

The IHF also has the capability to receive HLW canisters and transfer them to codisposal waste packages, although such waste packages would not contain DOE SNF canisters. It is beneficial to minimize the number of codisposal waste packages that would be loaded with HLW canisters only. Accordingly, it is anticipated that only a small quantity of such waste packages would be produced in the IHF. Nevertheless, to preserve flexibility in the conduct of operations, it is assumed that as many as 1,000 HLW canisters could be processed in the IHF (BSC 2007, p. 21) requiring one canister transfer machine handling each. However, the event sequences associated with IHF and CRCF canister transfer machine direct exposures would be mutually exclusive because handling of all HLW canisters is already included in the CRCF event sequence frequencies.

In summary, the approach used in the PCSA to determine event sequence frequencies accurately captures the frequency for events that may span more than one waste form. Because of substantial differences in handling, throughput, robustness of waste form, and dose consequences, it would be inaccurate to combine event sequences across facilities and across waste forms.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC 2007. *Waste Form Throughputs for Preclosure Safety Analysis*, 000-PSA-MGR0-01800-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071106.0001.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 18: Provide the maximum residence time of a waste package in a TEV without exceeding the maximum operating temperature for TEV shielding. The applicant identifies thermal degradation of the TEV shielding as a potential occurrence if a loaded TEV were to stop for an extended period of time (BSC, 2008l, Section B1.4.5). The applicant estimated about 8.5 occurrences of extended stoppage of the TEV during the preclosure period (BSC, 2008l, Calculation "Subsurface Quantification BACKCHECK UPDATE LOCKED 03-10-08.xls") but screened out this branch of event tree SSO-ESD-04 on the basis of a zero probability for loss of shielding. The applicant screened out thermal degradation of the TEV shielding because of a requirement established by the applicant that the shielding be designed to sustain the thermal loading for all waste package loadings over an extended period of time without significant degradation of the shielding function. The design requirement, however, includes undefined terms such as "extended period of time" and "significant degradation".

1. RESPONSE

1.1 PROBABILITY OF OCCURRENCE OF A LOSS OF SHIELDING EVENT

Steady-state thermal calculations for the 5-DHLW/DOE Short and Long Codisposal, 21-PWR/44-BWR transportation, aging, and disposal (TAD), and Naval Long and Short waste packages inside a transport and emplacement vehicle (TEV) demonstrate that the maximum operating temperature for the shielding materials is not exceeded. The calculations envelope the locations of the loaded TEV during its operations, including inside the Canister Receipt and Closure Facility and the Initial Handling Facility, in the geologic repository operations area during transit to the subsurface facility and throughout the subsurface during the emplacement process. The TEV shielding configuration considered for the calculations consists of the following layers of materials (listed from inside to outside): 316 Stainless Steel (SS) (1.5 in. thick), depleted uranium (1.5 in. thick), 316 SS (0.5 in. thick), NS-4-FR or an alternate material (6 in. thick) with thermal shunts or other thermal performance enhancing features, and 316 SS (0.5 in. thick).

Steady-state cases with the TEV standing continuously in 116°F (maximum ambient outdoor temperature) for the 5-DHLW/DOE Short Codisposal waste package in the TEV are analyzed with a heat load of 9.47 kW. Steady-state cases for the TAD waste package in the TEV are analyzed with waste package heat loads of 11.8 kW, 18 kW, 25 kW, and 30 kW. Steady-state cases for the Naval Short and Naval Long waste packages are analyzed with heat loads of 11.8 kW and axial thermal peaking of 5 kW/m. These calculations show that with heat loads less than 25 kW, the calculated temperatures at steady state are less than the maximum operating temperatures for the shielding materials in the TEV shielded enclosure. Since the limiting waste package power output for emplacement is 18 kW per waste package for commercial spent nuclear fuel (SNF) or 11.8 kW per waste package for Naval SNF (SAR Section 1.3.1.2.5 and Table 5.10-3), the probability for a thermally induced shielding failure is considered negligible, and a numerical value of zero was used as a reasonable approximation in the event tree.

1.2 THERMAL DEGRADATION OF THE SHIELDING MATERIAL

Among the materials described above for the TEV shielding configuration, the neutron shielding is the most susceptible to degradation due to exposure to high operating temperatures. The maximum continuous operating temperature of NS-4-FR, as determined by its manufacturer, is 300°F or 148.9°C. As long as the NS-4-FR surface temperature is maintained at temperatures less than 300°F during a TEV thermal transient event, there is no thermal degradation of NS-4-FR. The calculation discussed above demonstrates that the NS-4-FR inner surface temperature is 116°C for the 5-DHLW/DOE Short Codisposal waste package and 145°C for the 21-PWR/44-BRW TAD waste package with a heat load of 25 kW. The calculated NS-4-FR inner surface temperature is 109°C for the Naval Short waste package and 108°C for the Naval Long waste package with a heat load of 11.8 kW and axial thermal peaking of 5 kW/m. Each of the waste package configuration operating temperatures is less than the NS-4-FR maximum continuous operating temperature of 148.9°C (300°F).

Although thermal analyses indicate that the operating temperature for the NS-4-FR in the TEV shielding configuration is maintained less than its maximum continuous operating temperature of 148.9°C (300°F) throughout the range of TEV operations, some degree of degradation or aging in the NS-4-FR could occur over the operating life of the TEV. To ensure that the ongoing radiation protection capabilities of the TEV shielded enclosure satisfy worker health and safety requirements, routine inspections and operational surveys will be performed to monitor the performance of the NS-4-FR. In addition, the TEV preventive maintenance program, which will include evaluation and periodic replacement of TEV components to maintain operability and reliability performance, will routinely assess the shielding effectiveness of the shielded enclosure and address replacement as deemed necessary.

1.3 TEV SHIELDING DESIGN REQUIREMENT

A TEV shielding requirement is stated in *Subsurface Operations Reliability and Event Sequence Categorization Analysis* (BSC 2008), Section B1.4.5.3 as:

The TEV shielding is able to sustain the thermal loading for all waste package loadings over an extended period of time without significant degradation of the shielding function.

“Extended period of time” is defined as 30 days, which is a reasonable period of time to perform repairs and to restore systems to normal operations. The design requirement for TEV shielding is 100 mrem/hr at 30 cm from the external surface of the TEV (SAR Section 1.10.3.6.1). This design requirement is met with considerable margin (~50%). Exceedance of this design requirement is defined as “significant degradation.” The aforementioned inspection program will provide the means to identify and address any potential reductions in margin.

2. COMMITMENTS TO NRC

None.

ENCLOSURE 7

Response Tracking Number: 00306-00-00

RAI: 2.2.1.1.3-3-018

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC 2008. *Subsurface Operations Reliability and Event Sequence Categorization Analysis*. 000-PSA-MGR0-00500-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080312.0034.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 19: Provide information on probability of occurrence of an initiating event related to improper material selection for neutron absorber plates/tubes.

According to SNL (2007) Section 6.2.6, the WHF pool CSNF staging racks would contain neutron absorber plates. Many canisters and casks containing neutron absorber plates/tubes will be processed in WHF, will be filled up with and/or immersed in water. SNL (2007) Section 6.3.2 analyses estimate that material selection error during manufacturing process may exceed 10^{-4} per selection event (i.e., single plate/tube manufacturing). This analysis is used to quantify the improper performance of the neutron absorber plates (SNL, 2008, p. 6-823). The total number of manufactured plates used in canisters and casks (i.e., number of selection events) is expected to be very large. If wrong (i.e., out-of-specification) material is selected for neutron absorber plates used in the WHF pool, in canisters, and casks to be processed at WHF, the neutronic reactivity of the corresponding system might potentially increase reducing subcriticality margin of safety.

Sandia National Laboratories 2007. "Analysis of Mechanisms for Early Waste Package/Drip Shield Failure." ANL-EBS-MD-000076 Rev 00. Las Vegas, Nevada: Sandia National Laboratories.

Sandia National Laboratories 2008. "Features, Events, and Processes for the Total System Performance Assessment: Analyses." ANL-WIS-MD-000027. Rev. 00. Las Vegas, Nevada: Sandia National Laboratories.

1. RESPONSE

There are no Category 1 or Category 2 event sequences that require crediting fixed neutron absorbers. Therefore, material selection errors during manufacturing of such absorbers need not be considered for preclosure criticality safety as is done for postclosure criticality analyses.

For preclosure criticality safety of commercial and DOE spent nuclear fuels, initiating events are identified only if they impact a parameter that has been determined as needing to be controlled. The preclosure criticality analysis process for determining criticality control parameters is described in SAR Section 1.14.2.3.2. To screen the parameters that are important to criticality control during the preclosure period, k_{eff} sensitivity calculations are performed for each specific waste form that covered the possible conditions to which the waste form may be exposed during handling operations in the surface and subsurface facilities. These calculations evaluated the impact on system reactivity of variations in each of the parameters that could be important to criticality during the preclosure period. These criticality calculations provided guidance to hazards and initiating events identification (SAR Section 1.6) and to event sequence development, quantification, and categorization analyses (SAR Section 1.7) on whether each parameter:

- Does not need to be controlled because it is bounded or its effect on k_{eff} is bounded

- Needs to be controlled if another parameter is not controlled (conditional control)
- Needs to be controlled because it is the primary criticality control parameter.

Hazards identification and screening, as described in SAR Section 1.6, followed by event sequence development and quantification, as described in SAR Section 1.7, are performed only if a parameter must be controlled.

As summarized in SAR Section 1.14.2.3.2.5, fixed neutron absorbers need to be controlled for preclosure criticality safety only if moderation is introduced inside breached canisters for dry operations or if there is an insufficient concentration of soluble boron for wet operations, such as in the Wet Handling Facility. This determination is based on the sensitivity calculations involving fixed neutron absorbers described in SAR Sections 1.14.2.3.2.1.3, 1.14.2.3.2.2.4, and 1.14.2.3.2.3.3 for the various operations (wet and dry) as well as the various waste forms (commercial and DOE spent nuclear fuel). Because there are no Category 1 or Category 2 event sequences resulting in moderation being introduced inside breached canisters for dry operations or causing insufficient concentration of soluble boron for wet operations (SAR Tables 1.7-9 through 1.7-18), fixed neutron absorbers do not need to be controlled for preclosure safety of commercial spent nuclear fuel, unlike controls required for postclosure safety. Therefore, there are no initiating events related to improper material selection for neutron absorber plates or tubes relevant to the preclosure criticality safety analysis.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 21: Demonstrate that potential critical conditions that could occur without breach are accounted for in the screening process.

Justify:

1. How the IHF cask/canister mechanical handling would prevent more than two naval canisters from interacting.
2. Screening out interaction between more than four DOE SNF canisters in the CRCF, and provide information on those human actions and design solutions that are credited in screening out this initiating event.

Some of the DOE SNF does not require the introduction of moderator to reach an ‘important to criticality’ end state. However, there are no initiating events that deal with this nor is it clear how these initiating events were screened.

1. RESPONSE

Potentially critical configurations for commercial spent nuclear fuel (SNF), DOE SNF, and high level waste canisters, that could occur without breach or require the introduction of moderator are accounted for in the sensitivity analysis and the screening process described in SAR Section 1.14.2.3.2. To screen the parameters important to criticality control for commercial SNF and DOE SNF during the preclosure period, k_{eff} sensitivity calculations are performed for each specific waste form that includes the possible conditions to which the waste form may be exposed during handling operations in the geologic repository operations area. The two interaction conditions listed in the RAI are identified as the only conditions having potential for criticality without breach or the introduction of moderator.

The calculations are in *Nuclear Criticality Calculations for the Wet Handling Facility* (BSC 2007a), *Nuclear Criticality Calculations for Canister-Based Facilities—Commercial SNF* (BSC 2007b), and *Nuclear Criticality Calculations for Canister-Based Facilities—DOE SNF* (BSC 2008a). These calculations evaluate the impact on system reactivity of variations in each of the parameters that could be important to criticality during the preclosure period.

The criticality safety evaluation of naval SNF canisters involving configurations that could occur without breach is described in Section 1.14 of the Naval Nuclear Propulsion Program Technical Support Document.

1.1 INTERACTION CONTROL FOR MORE THAN TWO NAVAL SNF CANISTERS

The basis for screening out interaction between more than two naval canisters is presented in Table 6.0-2 of *Initial Handling Facility Reliability and Event Sequence Categorization Analysis* (BSC 2008b). The IHF material flow path, as presented in SAR Figure 1.2.3-16, and the handling equipment within the IHF physically preclude configurations that result in interaction between more than two naval canisters (BSC 2008b, Table 6.0-2, pp. 103–105).

1.2 INTERACTION CONTROL FOR MORE THAN FOUR DOE SNF CANISTERS

The basis for screening out interaction between more than four DOE SNF canisters is presented in Table 6.0-2 of *Canister Receipt and Closure Facility Reliability Event Sequence Categorization Analysis* (BSC 2008c). The probability of interaction between more than four DOE SNF canisters within the CRCF is less than 1×10^{-4} over the preclosure period (BSC 2008b, Table 6.0-2, pp. 103–104).

SAR Section 1.14.2.3.2.3 and Section 2.3.2.3 of *Preclosure Criticality Safety Analysis* (BSC 2008d) provide additional information regarding the criticality calculations that resulted in requiring interaction control. Specifically, Section 2.3.2.3.4 of *Preclosure Criticality Safety Analysis* (BSC 2008d) concluded that, for a closely-packaged infinite array of DOE standardized SNF canisters, only canisters containing Fast Flux Test Facility, Fermi, and Ft. St. Vrain SNF have the potential to exceed the upper subcritical limit of 0.89. The analysis that concluded that the upper subcritical limit may be exceeded for an array of five closely-packed Fast Flux Test Facility canisters, which was determined to be the most limiting fuel type, assumed optimally reflected conditions.

Therefore, potential critical conditions that could occur without breach or the introduction of moderator are accounted for in the screening process, and the only identified interaction conditions with potential for criticality are precluded based on facility designs and physical interlocks.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2007a. *Nuclear Criticality Calculations for the Wet Handling Facility*. 050-00C-WH00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071212.0001; ENG.20080331.0008.

BSC 2007b. *Nuclear Criticality Calculations for Canister-Based Facilities - Commercial SNF*. 000-00C-MGR0-03600-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071106.0033; ENG.20080317.0004; ENG.20080516.0003.

BSC 2008a. *Nuclear Criticality Calculations for Canister-Based Facilities - DOE SNF*. 000-00C-MGR0-03900-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080107.0028; ENG.20080211.0013.

ENCLOSURE 9

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RAI: 2.2.1.1.3-3-021

BSC 2008b. *Initial Handling Facility Reliability and Event Sequence Categorization Analysis.* 51A-PSA-IH00-00200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080312.0031; ENG.20080406.0002.

BSC 2008c. *Canister Receipt and Closure Facility Reliability and Event Sequence Categorization Analysis.* 060-PSA-CR00-00200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080311.0031; ENG.20080331.0007.

BSC 2008d. *Preclosure Criticality Safety Analysis.* TDR-MGR-NU-000002 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080307.0007.